RELATIVE VALUE OF SOME OF THE LEADING MILKING MACHINES AS MEASURED BY RATES OF MILK FLOW DURING THE MILKING PROCESS, COMPLETENESS OF MILKING, AND EASE OF CLEANING AND HANDLING

by

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INTRODUCTION

Today, the milking machine has largely replaced the human hand in the dairyman's greatest labor problem, that of milking. Though attempts (15) were made as early as 130 years ago to mechanically milk a cow, the first patents were not let on the vacuum principle until 1851. Then (15) it was not until the early nineteen-hundreds that the milking machine began coming into use.

Recently, a great deal of attention has been paid to the mechanical removal of milk from the udder. Many brands of milking machines have been marketed and today there are reportedly sixty some different brands in operation. These machines differ widely in construction and operating principles. Specified pulsation rates vary from 48 to 160 pulsations per minute and vacuum levels vary from 10 to 15 inches of Hg. Some of the units are suspended from the cow's back whereas others are placed on the floor. Also teat cup design is a highly variable factor among brands. Because of these wide variations, owners and prospective buyers of milking machines are confused as to which mechanical features are the most efficient. Research in this field has been focused largely on the physiological aspects of milking. Little experimental attention has been given to the mechanical features of milking machine operation.

This experiment was designed as a preliminary investigation to determine if cows respond differently to milking machines employing rather wide differences in mechanical design. The primary objects were threefold as follows:

1. To determine the relative rates of milk flow when cows were milked by different machines;

2. To determine the relative completeness of milking as shown by the amounts of handstrippings obtained after machine milking;

3. To compare the ease of handling and cleaning each machine.

REVIEW OF LITERATURE

It has been well established by Gaines (14) and Turner (33) that all of the milk obtained at a milking is present in the udder at milking time. It has also been established (14, 33, 10) that a hormone or hormones from the pituitary gland is associated with milk let down. Ely and Petersen (10) postulated that the release of this hormone is brought about by a nerve stimulus, either of a sensory nature resulting from contact with nerve endings in the teats and floor of the udder, or from a conditioned reflex associated with the usual noises and activities at milking time. They further postulated that the hormone involved is oxytocin from the posterior lobe of the pituitary gland, and that it acts on

smooth muscle in the udder causing it to contract, thus forcing milk out of the alveoli and small ductules. They presented evidence that adrenaline is responsible for a cow holding up her milk.

This theory has been widely accepted and much of the more recent research dealing with milking methods has been predicated on this theory. It has been found by Smith and Petersen (30) and Knoop and Monroe (18) that proper stimulation, usually by cleaning and massaging the teats and floor of the udder, was necessary for rapid mechanical milking. Various temperatures of the water used in cleaning the udder have been tried, because it was believed that warmth contributed to maximum stimulation, but Dodd and Foot (7) and Knoop and Monroe (18) found that there was little if any difference in the amount of stimulation created from using hot or cold water. It has been demonstrated by Miller and Petersen (21), Ward and Smith (35), and Beck (2) that a delay of five minutes or over between stimulation of the cow and application of the unit causes a decrease in rate of milk flow.

One of the basic problems involved in this field of research has been to establish methods of measuring the responses of cows to the milking act. In the early work of Matthews et al. (19), Foot (13), and Dodd and Foot (7, 8) the milk pail was suspended on a scale and the weights read at regular intervals. This method was also used by Petersen (22) and Smith and Petersen (29, 30) in studying the effect of me-

chanical features of milking machines on the rate of flow. Whittleston (36) seems to be the first to use an automatic electrical recording apparatus in recording the milk flow curve. Later, Beck et al. (4) used a continuous feed kymograph to obtain the rate of milk flow from the udder. Knoop and Monroe (18) reported the use of latex bags within the pail of a suspended type milking machine. By using a specially designed control valve on the lid of the unit they were able to catch two different portions of the milk during the initial period of milk flow.

Of several methods proposed for interpreting the milk flow graphs, Beck et al. (4) have suggested the use of a simple objective measure; namely, the per cent of total milk obtained during the first two minutes of milking (%2 M). They obtained a highly significant correlation coefficient of 0.922 between %2 M and machine time.

Beck et al. (3) used a kymograph in studying the repeatability of the milking response within cows. They found that the milk flow curve was highly repeatable from day to day for three consecutive days, week to week for six consecutive weeks, and from lactation to lactation during corresponding stages of two successive lactation periods.

In this same study, however, they found that there was a significant difference within cows from early to middle and middle to late stages of lactation. From 144 graphic milk flow records of 48 cows during each of early, middle, and late

stages of the same lactation period, Beck et al. (3) found that yield decreased 33 per cent from early to mid-lactation and 64 per cent from early to late lactation. Average rate of flow was found to decrease 13 per cent from early to mid-lactation and 48 per cent from early to late lactation. Maximum rate of flow was found to decrease 9 per cent from early to mid-lactation and 38 per cent from early to late lactation. Machine time was found to decrease 24 per cent from early to mid-lactation and 32 per cent from early to late lactation.

Several workers, Petersen (22), Foot (13), Dodd and Foot (8), and Beck et al. (3), have pointed out that there is great variation in the rate of flow among cows, and concluded that it is an individual characteristic which is perhaps inherited. Beck et al. (3) obtained a total of 306 graphic milk flow records over a three year period from 102 cows during peak flow and found that machine time ranged from two to seven minutes. Approximately 76 per cent of the cows milked out in four minutes or less and 39 per cent in three minutes or less. The maximum rate of flow varied from 3.4 to 12.8 pounds per minute with 80 per cent of them ranging from 4 to 10 pounds per minute. In average rate of flow, Beck et al. (3) ranked the breeds Holstein, Jersey, Ayrshire, and Guernsey. Holsteins had a significantly higher rate of flow than the other three breeds. Jerseys and Ayrshires were not significantly different whereas Guernseys were significantly lower than the other three breeds. They also furnished additional

evidence that the rate of flow is heritable. Of the 102 cows in the experiment, 74 were sired by 14 sires. When compared in an analysis of variance, statistically significant differences in the speed of milk withdrawal were obtained between the daughters of one sire as compared to the daughters of another sire within the same breed.

In two different experiments, Dodd and Foot (7, 8) attempted to alter the maximum rate of milk flow, first by decreasing normal milking time as much as 60 per cent of the previous normal and then by removing the machine before milk flow stopped, but failed to change the maximum rate of flow.

Some research has been done in comparing the mechanical features of milking machines. One of these features which has been studied is vacuum level. Petersen (22) stated that milk flow rate is roughly inversely proportional to hardness of milking and in 1944 presented data showing statistically significant differences in milk flow rates when cows were milked at different levels of negative pressure. Smith and Petersen (29) found when milking cows with 10, 12, 14, and 16 inches of vacuum, the milking time in minutes and seconds was 4:10, 3:44, 3:18, and 2:55, respectively. These differences were highly significant. They also found that for each increase in vacuum there was a significant increase in rate of flow. Another interesting phase of the vacuum studies (1, 29) showed that the per cent of total milk obtained when the end point of machine milking was reached increased on

vacuum levels of 12, and 14 over 10, but decreased on 16 inches of vacuum. Baxter et al. (1) compared the rates of flow of two rear quarters on four cows when subjected to milking by teat cup as compared to milking by cannula at 11, 16, and 20 inches of vacuum. When milked with 16 inches of vacuum, the eight quarters were emptied at significantly different maximum rates by teat cup but at nearly the same rate through the teat cannula, suggesting that the teat orifice is a very important factor controlling the rate of milking. The maximum rate of milking by both teat cup and teat cannula increased with increasing levels of vacuum from 11 to 20 inches Hg. The rate of increase in the teat-cup milking was greater than in the cannula milking, suggesting that the teat orifice was opened wider at the higher levels of vacuum.

It is interesting to note that in spite of the fact that all machines in this country have a pulsation ratio of 1:1, Smith and Petersen (29) found an increase in rate of flow at each vacuum level for ratios of 3:1 and 2:1 over the standard ratio of 1:1.

Contrary to this, Whittleston and Verrall (40) and Whittleston (38) concluded that the cow is generally the limiting factor in the milking process since a pulsation rate of 21, 42, and 84 pulsations per minute and line vacuums of 10, 15, and 19 inches of Hg. failed to give any significant changes in milk flow rates.

Ever since milking machines first came out, the question has been raised as to the amount of injury caused to the udder tissue by mechanical milking. Meigs et al. (20), Kennedy (16), Petersen (22, 23, 24, 25), and Espe (11) have indicated that there is a real danger of injuring the mammary tissue when the machine is left on the udder after milk flow has ceased. Petersen (23) demonstrated how vacuum develops within the teat equal to that in the line when the teat cups crawl upward to cause a complete closure of the orifice between the teat and gland sinuses. This crawlin occurs only when intra-glandular pressure is sufficiently reduced. He concluded that crawling may cause incomplete machine milking unless machine stripping is practiced, thereby permitting complete evacuation of all milk in the gland. Petersen (23) and Espe (11) state that if the machine is properly operated, there is less danger of injury to the teat and udder than from hand milking.

The only place in the literature that any mention is made of comparing one commercially made milking machine with another is that of Udall (34). He reports that after changing from a high vacuum to a low vacuum machine, routine monthly examinations showed a reduction of 50 per cent in the number of cows reacting to the bromthymol-blue test, that medium grades of mastitis showed a marked decrease, and that significant teat erosions, prevalent while milking with the first machine, completely disappeared.

EXPERIMENTAL PROCEDURE

Nine different milking machine units were employed in this experiment. These units were furnished by seven different manufacturers.[1] Six of these units were of the upright, pail-type design, while three of the units were of the suspended type. One unit was used during two different experimental periods, with different teat cup inflations during each period.

A one inch pipeline was installed in the milk barn in order that the vacuum line would meet the specifications of all of the milking machine companies. This was in keeping with the policy that each machine be operated according to factory specifications. Factory representatives were invited to be present while their machine was being used and in nearly all cases a representative was present, at least for the first milking. Each company was given the opportunity to furnish its own pump if desired. The order in which the machines were used in this experiment was randomly determined. Listed as follows are the specifications under which the machines were

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[1] The seven milking machine manufacturers are: Babson Bros. Co., 2843 West Nineteenth Street, Chicago 23, Illinois; The DeLaval Separator Co., 165 Broadway, New York 6, New York; Hinman Milking Machine Co., Inc., Oneida, New York; International Harvester Co., 180 North Michigan Ave., Chicago 1, Illinois; J. C. Marlow Milking Machine Co., Mankato, Minnesota; Riteway Products Co., 1241-7 Belmont Ave., Chicago, Illinois; Universal Milking Machine Div., Waukesha, Wisconsin.

operated.

Milking machine unit	Type	Vacuum (inches of Hg.)	Pulsations per min.	Pump used
DeLaval	Upright	12.5	48	DeLaval
Hinman	Upright	10.0	60	Hinman
Hinman	Upright	10.0	60	Hinman
International	Upright	13.0	50	Surge
Marlow	Upright	10.0	120	Marlow
Riteway	Suspended	14.0	50	Surge
Riteway	Upright	14.0	50	Surge
Surge	Suspended	15.0	48	Surge
Universal	Suspended	10.0	50	Surge
Universal	Upright	11.0	50	Surge

All milking machines were operated on a pulsation ratio of 1:1. In all cases new rubberware was used.

Sixteen cows, four from each of the Ayrshire, Guernsey, Holstein, and Jersey breeds, were randomly selected from all cows in the College herd that had reached their peak production and had at least two months of their lactation remaining. At the end of the first two experimental periods it was deemed advisable to drop four of the lowest producing cows and substitute four higher producing cows so that the average level of production was more nearly comparable to that of a good farm herd. Hence, a substitution was made for one cow in each of the four breeds. Three of the four replacement cows were slow hard milkers.

Two men were employed to operate the milking machines, one throughout the a.m. milkings and the other throughout the p.m. milkings. A standard milking procedure was followed throughout, which consisted of wiping the teats and the floor

of the udder with a damp cloth for approximately 20 seconds, followed by foremilking two full hand squeezes of milk into the strip cup from each quarter. An interval of one to two minutes between the preparation of the cow and the beginning of milking was allowed.

Before starting the experiment proper, it was deemed advisable to have a preliminary period of two weeks for the purpose of establishing the best working plan, familiarizing the machine operators with the experimental techniques, and allowing the cows to become adjusted to their new surroundings. The cows selected for this experiment had been milked with a DeLaval milker in a 70 cow stanchion-type barn. The experiment was conducted in an 18 stall barn which was free from visitation and the general activities of the larger barn. During this two week preliminary period two different milking machines were used.

Based on observations made during the preliminary period it was decided that a five day teat period for each machine was adequate for the purposes of this experiment. Therefore each machine was used for five consecutive days with the exception of two machines that were used six and seven days, respectively. These machines were held over the extra days to allow milking machine company representatives to be present at the beginning of the next experimental period. The experiment lasted a total of 53 days.

Yields of milk obtained with the milking machines and by

hand stripping were weighed and recorded separately for each milking throughout the entire experiment. Graphic milk flow rates were measured with a specially designed kymograph[1] during the last three days of each experimental period in which the upright milking units were used. This type of measurement was not adaptable for use with the suspended-type milkers. Therefore, the percentage of total milk yield obtained during the first two minutes of milking was determined as a measurement for comparing all of the machines as to speed of milk withdrawal. This measurement was made by removing the suspended-type milker unit from the cow after two minutes of milking and weighing the milk. Where the kymograph was employed the amount of milk obtained during the first two minutes of milking was obtained directly from the graph.

The time that the milking unit was on each cow was measured with a stop watch. In the case of the suspended-type machines, the time required to weigh the milk at two minutes was deducted. Notes were taken on general ease of handling each machine, its characteristics, and of any irritation of the cows as evidenced by kicking, switching tails, etc. The time required to set each unit up and its cleaning time were also recorded. A standard cleaning procedure was followed. All of the suspended-type milkers were rinsed in cold water, taken completely apart and brushed clean in a hot cleaning

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[1] Obtained from David C. Brewer Special Service Co. of Saint Paul, Minnesota.

solution, rinsed again, placed in a hot water bath and then stored dry. All of the upright-type machines were only partially taken apart since they were adapted to the solution rack method of storage. They were cleaned without the hot bath and stored in a solution rack with a lye solution in them. Otherwise, the cleaning procedure was identical for both types.

EXPERIMENTAL RESULTS

Milk Yield

This experiment was not designed to compare the effect of milking machines on milk yield. It is of interest, however, to note that milk yield was not grossly affected by any particular machine used in this experiment. As shown in Table 1, there was a gradual decline in milk yield from the preliminary period to the end of the experiment, without any violent changes occurring within any one period. There was an average drop in milk yield of about 20 per cent during the 53 day experimental period. While this decrease may be somewhat abnormal, it could not be attributed to any one machine, but probably was due to the frequent changes of milking machines.

Table 1. Average daily milk production of cows over a 53 day period when milked with 10 different milking machines.

Breed	No. of cows	Pounds of milk per day during each milking period									
		Preliminary	Milking machines								
			A	B	C	D	E	F	G	H	I	J
Holstein	3	37.8	38.2	38.0	37.4	37.1	37.1	36.9	34.8	33.6	35.3	32.8
Ayrshire	3	23.3	22.6	21.8	21.6	20.8	21.5	21.0	19.4	18.7	18.5	17.1
Guernsey	3	27.5	25.8	25.7	26.3	25.5	25.5	24.6	23.7	23.0	23.4	21.2
Jersey	3	19.5	19.5	18.0	17.9	17.7	18.8	17.9	16.0	16.4	16.4	15.3
All breeds	12	27.0	26.5	25.9	25.8	25.3	25.7	25.1	23.5	22.9	23.4	21.6

Speed of Milking

In comparing the various milking machines as to their respective speed of milk withdrawal, it might appear that the length of time each unit remains on the cow would be the most acceptable measurement, however, unless some instrument such as the kymograph is used, the length of time the machine is left on the cow is dependent entirely on the operator's judgment. In this experiment the kymograph could not be used on the suspended-type of milking units. Therefore, percentage of total milk yield obtained during the first two minutes of milking (%2 M) was used as the basis for comparing the milking machines for speed of milking. This appeared to be a valid measurement since it was applied objectively to all machines and since it has been shown (4) to be highly correlated with machine time where machine time was objectively measured.

Differences in milking speed among the various milking machines were apparent. As shown in Fig. 1 and Table 2, the average %2 M for the group of cows for each experimental period ranged from 52 for machine C to 67 for machine J. Cows from each of the four breeds showed similar differences in their responses to the milking machines. To determine whether these differences were of a significant nature an analysis of variance was run on all data using the averages of the group of 16 cows. The variation among cows was not considered

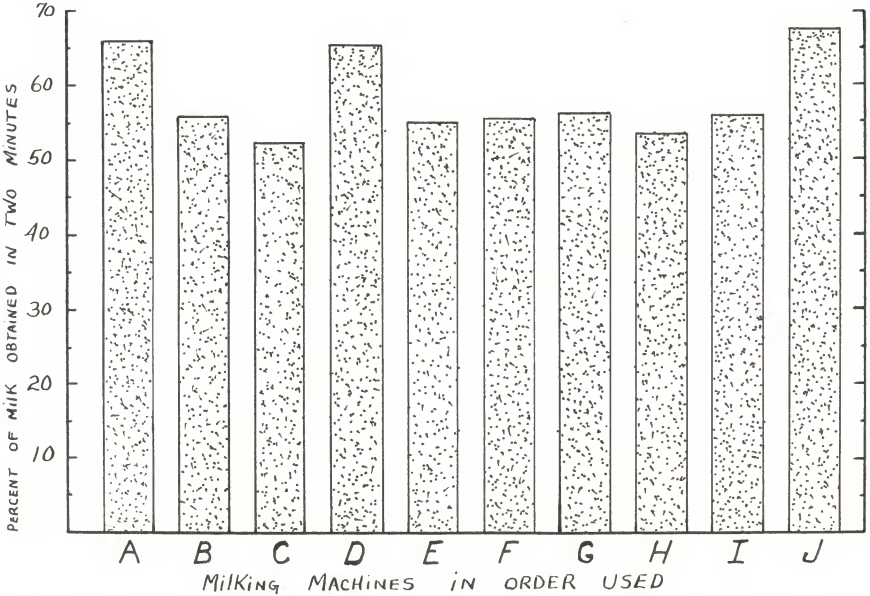

Fig. 1. Speed of milk withdrawal as shown by the average per cent of milk obtained in two minutes when milking 16 cows with 10 different milking machines during consecutive five day periods.

Table 2. Relative speed of milk withdrawal, as shown by the per cent of milk obtained in two minutes when 10 different milking machines were used during consecutive five day periods.

Breed	No. of cows*	Average per cent of milk yield obtained during the first two minutes of milking — Milking machines									
		A	B	C	D	E	F	G	H	I	J
Holstein	4	73	65	60	74	59	59	64	54	60	75
Ayrshire	4	60	57	51	65	52	53	58	54	52	64
Guernsey	4	53	44	42	56	44	44	45	42	45	59
Jersey	4	77	56	57	69	65	63	61	61	67	74
All breeds	16	66	56	52	65	55	55	56	53	56	67

* Only three cows of each breed were included during the regular five day test periods for machines A and B. Data were obtained for the additional four cows by milking with machines A and B during consecutive two day periods at the end of the experiment.

since it was known to be very great. The differences among machines proved to be highly significant. To determine which of these machines were actually different from each other a least significant difference of approximately 3 was calculated.

According to this least significant difference the machines may be grouped as follows:

Group I	Group II	Group III
J 67.5	G 56.5	H 53.5
A 66.0	I 56.0	C 52.5
D 65.5	B 56.0	
	F 55.0	
	E 55.0	

It is clearly evident that the machines within Groups I, II, and III are no different from each other, but that the outstanding difference lies between the machines in Group I and the rest of the machines. According to the statistical approach of Tukey (32), the milking machines in Group III came from a different population than the population that the milking machines in Group II come from. However, it appears obvious that the real difference of practical importance lies between the machines in Group I and the rest of the machines.

In studying the individual response of the cows to the various milking machines, it was noted that the relatively slow milking cows contributed more to the difference occurring between machines than did the fast milking cows. To show this more clearly the average responses of the six most rapid milking cows is compared with that of the four slowest milking cows for each machine, Fig. 2. As shown in Fig. 2, it

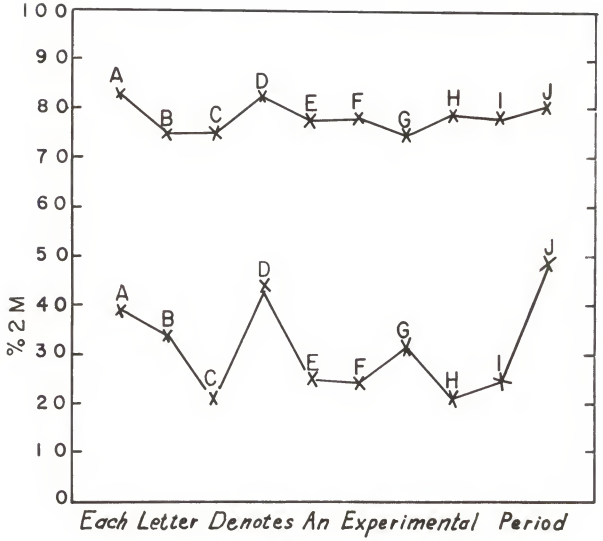

Fig. 2. Comparative milk flow rates from six fast milking cows (upper graph) and four slow milking cows (lower graph) when milked with 10 different machines.

is obvious that machines A, D, and J were much faster than the other machines in milking the slow milking cows, whereas there was little difference among machines in rate of flow from the fast milking cows.

As previously discussed, the total length of time the milking machine was left on each cow is not an accurate method of measuring differences in milking speed, because it depends on the operator's judgment as to when the cow is through milking. However, it is of interest to note that the machine time, as measured with a stop watch in this experiment for some machines and taken from kymograph readings with other machines, agrees well with the results obtained by using the more objective measurement ℳ2 M. The average machine time for machines A, D and J amounted to 4.4 minutes as compared with 5.1 minutes for the other machines, or a decrease of about 14 per cent in milking time.

Machines A, D and J were similar in two mechanical features. They operated at relatively high vacuum levels and relatively low rates of pulsation. It cannot be said that these two features were exclusively responsible for the faster rates of milking obtained by these machines because two other machines (B and G) likewise having these features, were among the slower milking machines. Two of the faster milking machines were of the suspended-type, but one of the faster machines was an upright, pail-type, so that suspension alone was not responsible for faster milking. Thus it is not

possible from the results obtained in this experiment to attribute faster milking exclusively to any particular mechanical feature.

It might be argued that the experimental periods were too short for the cows to become adjusted to a particular milking machine. Most representatives of the various milking machine companies involved thought that the cows would become adjusted to their machines within a five day period. However, there were some who thought that their machine should be used three or four months in order to obtain the best milking response. The results of this experiment showed that there was no appreciable change in the response of the cows from the first through the fifty day with respect to speed of milking. During the five days of each experimental period the daily mean values for $\bar{x}$2 M were 59.5, 59.5, 58, 58, and 58, respectively. The slight negative regression from the first through the fifth day is not statistically significant.

Completeness of Milking

Minor differences were noted in the performance of the various milking machines with regard to completeness of milking. As a measurement of completeness of milking the cows were carefully hand stripped after they had been machine stripped. The average yield of hand strippings (Table 3) ranged from 0.8 lb. per milking for machine E to 1.3 lbs. for

machine C. Although the differences in hand strippings were of doubtful practical importance they were highly significant statistically, when tested by the analysis of variance.

It was not possible to relate the thoroughness of milking with any particular mechanical feature. With the exceptions of machines B, C, and H, the other machines fell within the very narrow range of .8 to 1.0 lb. of hand stripping. The same milking machine was used in periods E and F with the exception that different style teat cup inflations were used in each period. The average yield of hand strippings in period E was 1.3 lbs. as compared with 0.9 lb. in period F. Thus it seems probable that the design of the teat cup inflations might be an important factor in completeness of milking.

Table 3. Hand stripping yields from 16 dairy cows milked during 10 consecutive five day periods with a different milking machine used in each period.

Breed	No. of cows*	Average pounds hand strippings per milking									
		A	B	C	D	E	F	G	H	I	J
Holstein	4	.8	.9	1.3	.8	.9	.8	1.0	1.1	1.0	.9
Ayrshire	4	.7	.8	.8	.5	.7	.7	.8	.9	.8	.6
Guernsey	4	1.4	1.9	1.9	1.4	1.3	1.4	1.5	1.9	1.5	1.1
Jersey	4	.7	1.0	.8	1.1	.5	.6	.8	.8	.6	.8
All breeds	16	.9	1.1	1.3	1.0	.8	.9	1.0	1.2	1.0	.9

* Only three cows of each breed were included during the regular five day test periods for machines A and B. Data were obtained for the additional four cows by milking with machines A and B during consecutive two day periods at the end of the experiment.

Effect of Machines on the Cows

Despite the fact that the milking machines were changed frequently, there were no serious outbreaks of mastitis throughout the duration of the experiment. Only two mild cases of mastitis occurred during the experiment, and these involved cows that had previously shown mastitis in the same quarters. Following treatment, these cows cleared up and gave no further trouble. These two cases of mastitis did not occur within the same experimental period.

The cows manifested more discomfort and uneasiness during the periods in which high vacuum machines were used. This was noticed especially in the frequency of kicking, stepping around and switching of tails.

Generally speaking, there was some teat cup crawling observed on some cows for all of the higher vacuum machines. Two units, H and I, left a deep indentation at the base of the teat on the top side of the teat cup.

Ease of Handling and Cleaning Machines

No particular machine was singled out by the operators as being especially easy to handle. They did favor the machines of light weight construction. They also favored having some feature provided that would permit seeing the milk flowing so that they could more easily determine when a cow

was through milking. One of the features liked especially well about the suspended-type machine was the ease of pouring milk. This was balanced off, however, by a dislike for the surcingle.

Some features of some machines were especially objectionable. In the case of machine E it was difficult to dip the teat cups between cows due to the wide spread of the claw. With unit B it was difficult to separate the rubber from the metal. In two cases, B and I, it was awkward to hang the claw on the pail. Machine stripping was difficult with the low vacuum units because the teat cups pulled off with relatively little pressure being applied.

The average total time required to milk the 16 cows with one unit is shown for each machine in Table 4. The 16 cows were milked 20 minutes faster with machines A, D, and J than with C, E, F, and H. It will be noted that machines G and I were relatively faster in the overall milking time than was indicated (Table 2) by their rates of milk flow. The overall milking time reflects not only the speed with which each cow is milked, but also the time required to transfer the unit from cow to cow.

In time required to assemble and clean each unit, machine E (Table 4) required the least and machines B and H the greatest amount of time. The saving in time here is so small as to be of doubtful commercial value. None of the units required an excessive amount of time for assembly and cleaning.

Table 4. Comparisons among nine different milking machines in time required to milk 16 cows and to assemble and clean each unit.

Machine	Total milking time hrs. & min.	Assembly time min. & sec.	Cleaning time min. & sec.	Total assembly and cleaning min. & sec.
A	1:35	2:00	4:00	6:00
B	1:50	2:50	3:40	6:30
C*	1:55	2:15	4:00	6:15
D	1:35	2:40	3:40	5:20
E	1:55	1:45	3:00	4:45
F*	1:55	2:15	4:00	6:15
G	1:40	2:15	3:00	5:15
H	1:55	2:30	4:00	6:30
I	1:45	2:00	3:50	5:50
J	1:35	2:15	3:30	5:45

* Same machine with different teat cup inflations.

DISCUSSION

In evaluating the foregoing results from the standpoint of practical application, the most significant difference obtained among the various milking machines was that of speed of milking. Three machines were definitely superior to the others in rate of milking. The time saved by these machines, which averaged about 40 seconds per cow, would be of practical importance especially in milking large herds of dairy cattle. It should be pointed out, however, that the main differences in speed of milking were obtained when milking slow, hard milking cows. The differences among the machines tested were so slight as to be of little importance when milking relatively fast, easy milking cows.

Whether or not the faster milking machines are more inclined to damage the udder tissue, especially when the machines are left on too long, is an important question that was not answered in this short time experiment. Only a long time experiment involving a large number of cows would establish the optimum rate of milking conducive to good udder health.

It was not possible from the results of this experiment to relate fast milking exclusively to any particular mechanical feature. It appears probable, however, that relatively high vacuum is an important feature, because each of the faster milking machines operated at relatively high vacuum levels. Furthermore, the results of Smith and Petersen (28, 29) and

of Baxter et al. (1) have demonstrated that faster milking can be accomplished with higher vacuum.

No serious handicap was presented by any machine used with regards to ease of handling and cleaning. Some machines had undesirable features that could be improved, but these were all of a minor nature that would not hinder efficient milking once the operator had become accustomed to the machines.

SUMMARY AND CONCLUSIONS

A group of 16 cows, including four each of the Ayrshire, Guernsey, Holstein and Jersey breeds, were milked during ten consecutive five day periods with a different milking machine used during each period. Nine different milking machines were used with one machine being repeated with a different style of teat cup inflation. Measurements and observations were made concerning the relative speeds of milking, completeness of milking and ease of handling and cleaning each machine. From the results obtained the following conclusions are made:

1. Milking machines differ significantly in speed of milking, especially with hard, slow milking cows. One of the features related to faster milking is a relatively high level of vacuum.

2. Although the differences obtained among machines in completeness of milking, as measured by hand stripping yields, were statistically significant, these differences were not

great enough to be of practical value.

3. Among the machines tested, none presented any serious handicaps with respect to ease of handling and cleaning.

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RELATIVE VALUE OF SOME OF THE LEADING MILKING MACHINES AS MEASURED BY RATES OF MILK FLOW DURING THE MILKING PROCESS, COMPLETENESS OF MILKING, AND EASE OF CLEANING AND HANDLING

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Since the milking machine has largely replaced the human hand in milking cows, it seems only normal that an investigation into the mechanical features of milking machines would come about. Some research has been done on certain phases of mechanical milking which are various amounts of vacuum, pulsation rates, and pulsation ratios and their effect on rate of milk flow from the udder and the completeness of milking.

To begin a study of the mechanical features among milking machines, it appeared that a logical approach would be to compare a number of the competent milking machines in present day use. If these machines proved to be different statistically, then further study could be outlined to determine what the cause of these differences would be.

The objectives of the experiment were to determine if there was any adjustment in the responses of cows over a five day period to each milking machine used and whether or not changing milking machines every five days for ten such periods affected the normal response of the cows, whether there were significant differences among the various milking machines in either the speed of milk withdrawal when measured by the per cent of total milk obtained during the first two minutes of mechanical milking (%2 M) or the completeness of milking when measured by the amount of hand strippings remaining after machine stripping had been completed.

Nine milking machines were supplied by seven different companies. Two of the companies supplied both a suspended

and an upright type of unit and one of the units was used in a duplicate period with different teat cup liners.

This made a total of ten milking machines. Each milking machine was used for a period of five consecutive days on 16 cows. The cows were milked under standard conditions and the milking machines were operated according to factory specifications.

The data collected at both the a.m. and p.m. milkings for each cow throughout the experiment included the pounds of milk obtained at two minutes of milking, at the completion of mechanical milking to include machine stripping, and from hand stripping. Machine time was also taken with a stop watch at each milking. The time required to set each unit up for use and its cleaning time was also clocked.

It was found that the average daily milk production from the five day preliminary period to the last experimental period dropped no more than might be expected for the group of cows as a whole. However, two cows within the group did drop abnormally in milk production at least one of which was probably due to the frequent change of milking machines. It seems of importance for future studies that cows can be milked with ten different milking machines over a period of 53 days without creating any violent disturbance in yields.

In comparing the milking machines for speed of milking the per cent of total milk obtained during the first two minutes of mechanical milking (%2 M) was used. The %2 M was pre-

viously found to have a high correlation coefficient of 0.922 with actual machine time when machine time was accurately recorded by use of a kymograph. Since it was impossible to use the kymograph when the suspended type of milking machine was being used the ⅔ M was adopted as a meausre for comparing the speed of milking of all machines throughout the experiment. By calculating a regression on ⅔ M of all machines from the first day through the fifty it was found that the small negative regression was nonsiginificant indicating that there was an immediate adjustment to each milking machine by the cows or that the adjustment was of such a long time nature that it could not be brought out by these data.

Of primary importance are the highly significant differences between machines when an analysis of variance was calculated on ⅔ M. By use of a least significant difference it was found that three machines were of a practical difference from the rest of them. These three machines were of the high vacuum type, but two other machines were also of high vacuum type indicating that vacuum level is not the only factor responsible for rapid milking. It was found that the three machines that were significantly faster milkers than the others were so largely because they milked out the slow milking cows at a much higher rate than did the rest of the machines.

In regard to machine time, which was clocked from the actual time the unit remained on each cow based on the operator's judgment of when mechanical milking was complete, there

were highly significant differences among machines in general agreement with the %2 M data.

Significant differences were also obtained for hand strippings of which the means for each machine ranged from 0.8 to 1.4 pounds. Since hand strippings are affected by judgment which determines when machine stripping is completed, it would be unwise to draw a fine line of distinction between the various machines.

The time required to set each unit up ready for use and its cleaning time ranged from 4 minutes and 45 seconds to 6 minutes and 30 seconds. Therefore it seemsthat none of the units required excessive time for setting up and cleaning.

Some features which the operators seemed to prefer among the machines were light weight construction, good balance, and a means for observing the milk flow.

Only two cases of chronic mastitis occurred during the entire experiment suggesting that cows can be milked with many different machines when the units are properly operated without causing an undue incidence of mastitis.